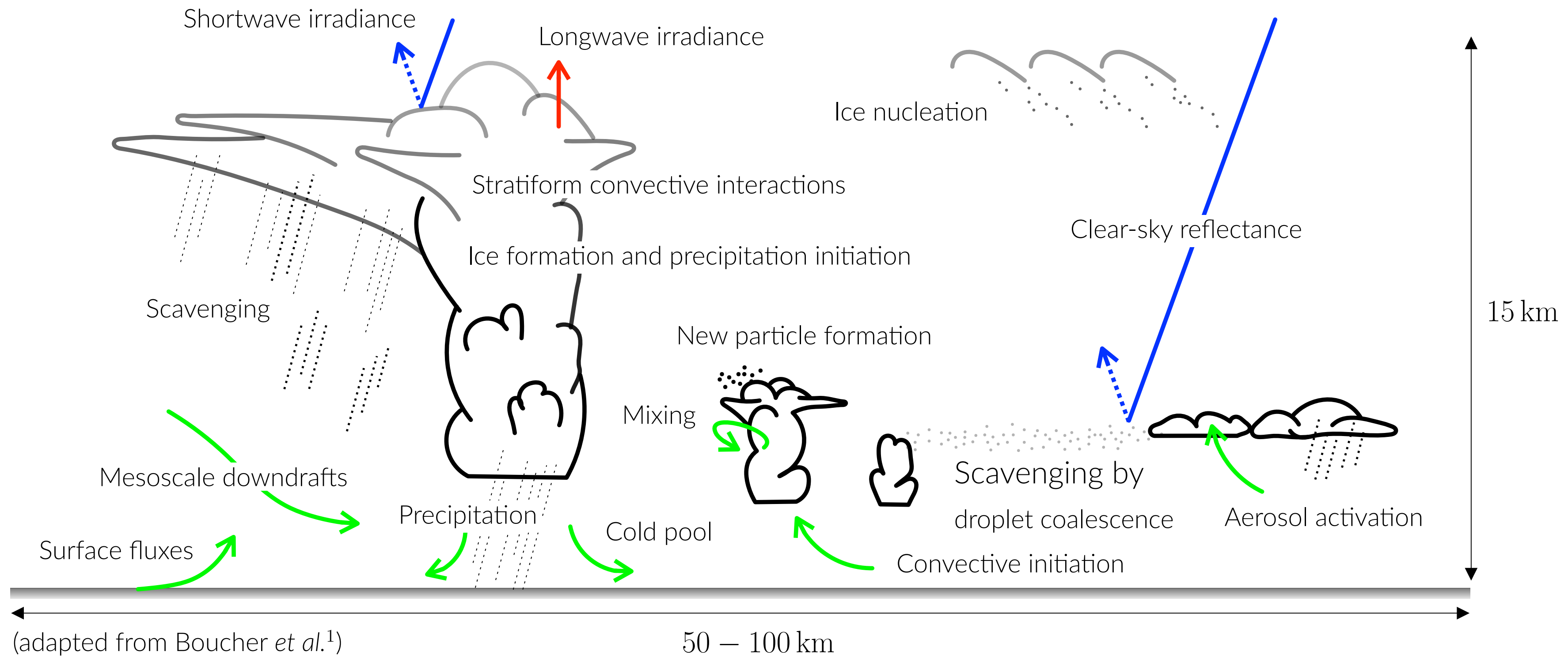
Anthropogenic aerosol perturbations in global storm-resolving simulations

Philipp Weiss[1] Ross Herbert[1] Andrew Williams[1] Daniel Klocke[2] Philip Stier[1]

[1]Department of Physics, University of Oxford [2]Max Planck Institute for Meteorology

Aerosols and clouds

Aerosols originate from natural processes, like dust storms or sea spray, but also from human activities, like biomass burning or fuel combustion. Despite their small size, aerosols strongly influence Earth's radiation balancex.[2] Aerosols scatter and absorb radiation referred to as aerosol-radiation interactions but also modify the properties of clouds, as cloud droplets form on aerosol particles, referred to as aerosol-cloud interactions.[1]



(adapted from Boucher *et al.*[1])

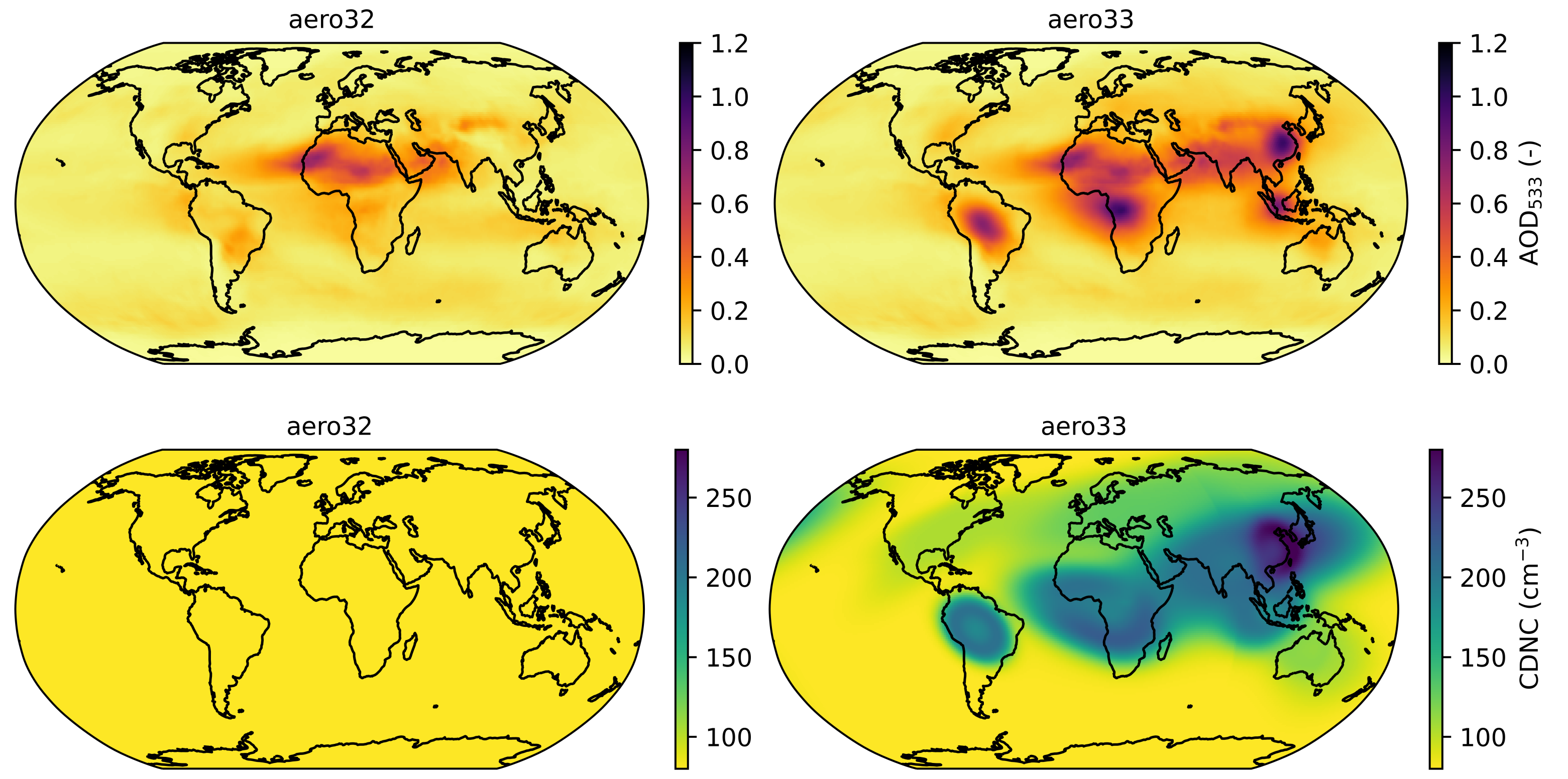
Storm-resolving simulations

Storm-resolving simulations resolve atmospheric motions on scales of about $5\,\mathrm{km}$ and consequently represent important atmospheric processes like convective updrafts that were parameterized previously.[6] Regional storm-resolving simulations revealed significant effects of aerosols on clouds and provided insights into the underlying processes and drivers.[4, 7, 5]

Our poster presents first results from global storm-resolving simulations. In contrast to regional simulations, global simulations include the coupling to large-scale circulation and in particular the budgetary constraints on precipitation due to the conservation of energy and water.[3]

Our simulations are performed with the atmospheric model ICON[10] in which aerosol perturbations are represented with the plume model MACv2-SP.[8] The sea surface temperature and sea ice are prescribed. Our analysis includes 40 days in the biomass burning season from 22th August to 30st September 2020.[9]

Figure 1. Overview of our simulations: reference (aero32) and perturbation (aero33).



Cloud water and ice

Figure 2. Global means of water vapor, cloud water, and cloud ice; vertically integrated. Shown is the difference between the perturbation (aero33) and reference (aero32).

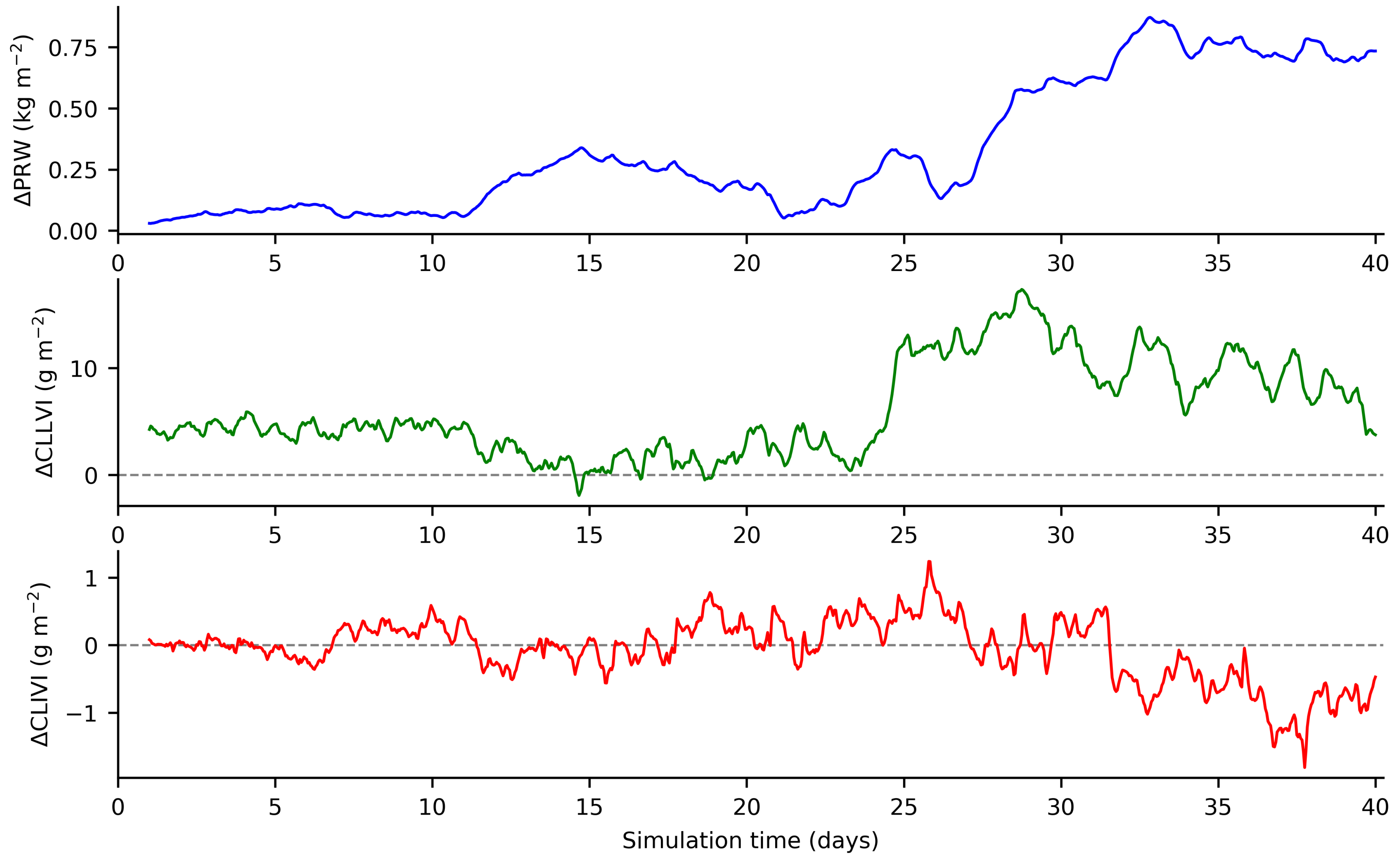
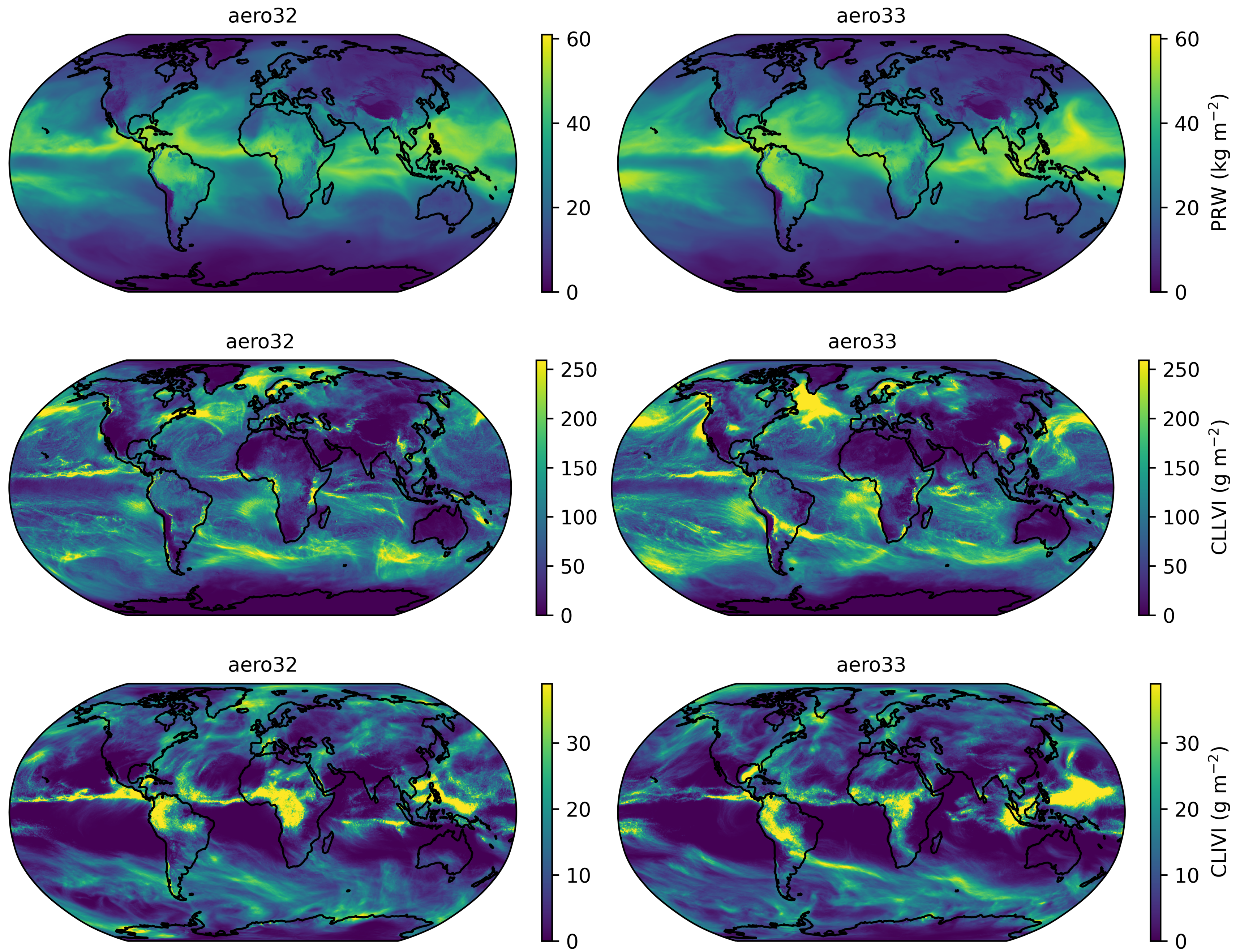


Figure 3. Maps of water vapor, cloud water, and cloud ice; vertically integrated and averaged from 20th to 30th September (from day 30 to 40).



Radiation fluxes

Figure 4. Global means of outgoing longwave and shortwave radiation at the top of the atmosphere. Shown is the difference between the perturbation (aero33) and reference (aero32).

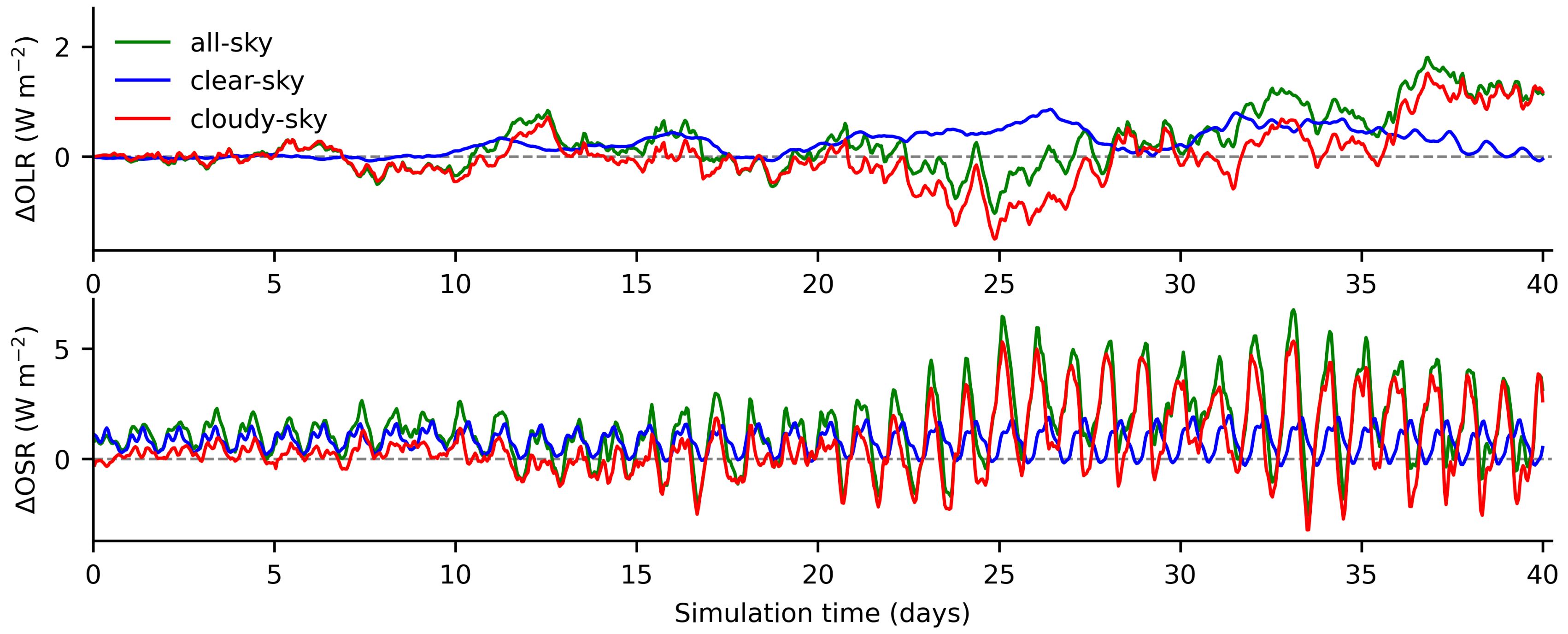
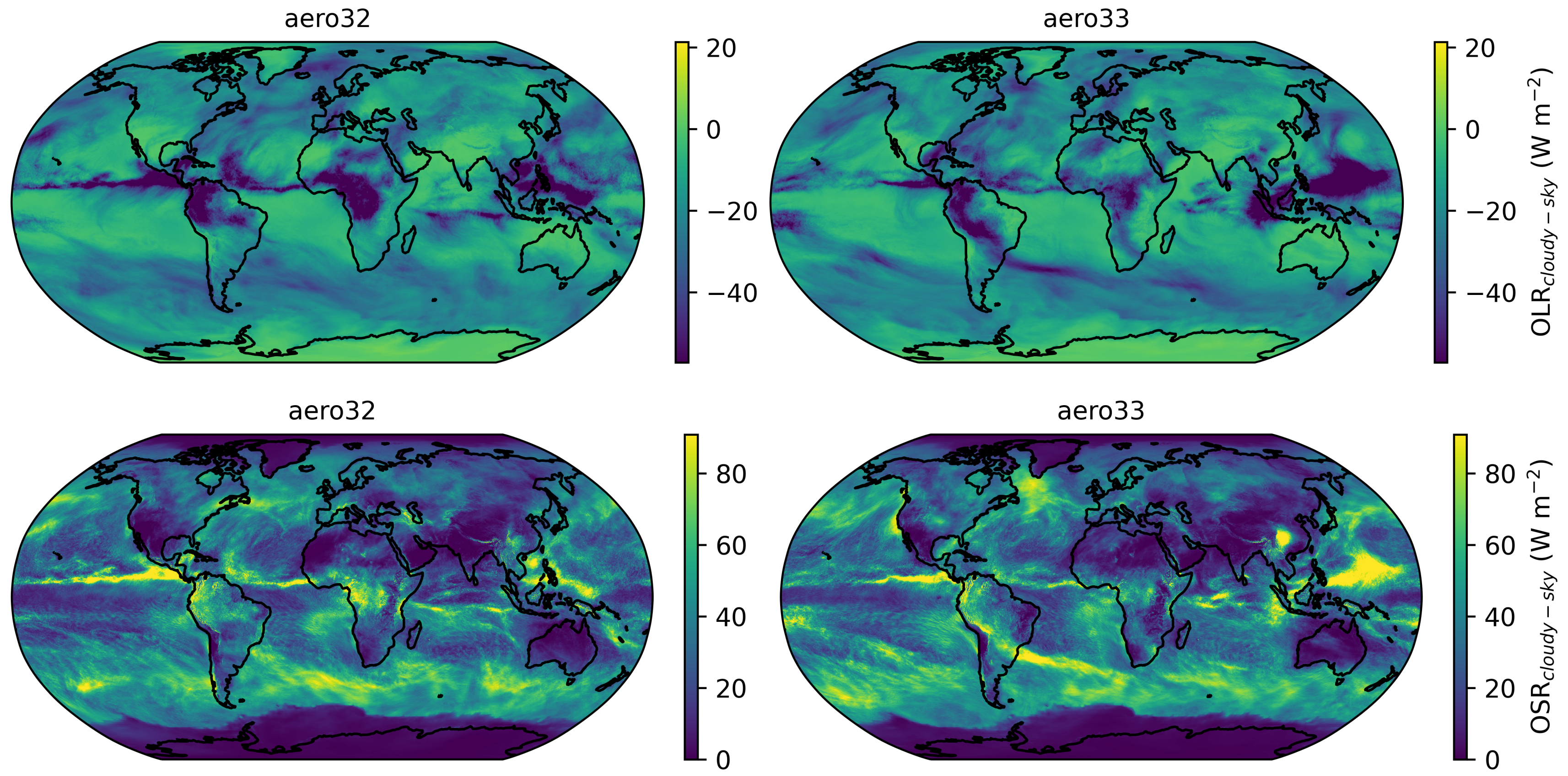


Figure 5. Maps of the outgoing longwave and shortwave radiation at the top of the atmosphere over cloudy sky; vertically integrated and averaged from 20th to 30th September (from day 30 to 40).



References

[1] Frida A.-M. Bender. *AGU Advances*, 1, 2020.

[2] O. Boucher, D. Randall, and P. Artaxo. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. T. F. Stocker and D. Qin and G.-K. Plattner, 2013.

[3] Guy Dagan and Philip Stier. *npj Climate and Atmospheric Science*, 3(34), 2020.

[4] Guy Dagan, Philip Stier, Matthew Christensen, Guido Cioni, Daniel Klocke, and Axel Seifert. *Atmospheric Chemistry and Physics*, 20:4523–4544, 2020.

[5] Ross Herbert, Philip Stier, and Guy Dagan. *Journal of Geophysical Research: Atmospheres*, 126, 2021.

[6] Cathy Hohenegger, Luis Kornblueh, and Daniel Klocke. *Journal of the Meteorological Society of Japan*, 98:73–91, 2020.

[7] Peter J. Marinescu, Susan C. van den Heever, Max Heikenfeld, Andrew I. Barrett, Christian Barthlott, Corinna Hoose, Jiwen Fan, Ann M. Fridlind, Toshi Matsui, Annette K. Miltenberger, Philip Stier, Benoit Vie, Bethan A. White, and Yuwei Zhang. *Journal of the Atmospheric Sciences*, 78(1147), 2021.

[8] Bjorn Stevens, Stephanie Fiedler, Stefan Kinne, Karsten Peters, Sebastian Rast, Jobst Müsse, Steven J. Smith, and Thorsten Mauritsen. *Geoscientific Model Development*, 10:433–452, 2017.

[9] Bjorn Stevens, Masaki Satoh, and Ludovic Auger. *Progress in Earth and Planetary Science*, 2019.

[10] Günther Zängl, Daniel Reinert, Pilar Rípodas, and Michael Baldauf. *Quarterly Journal of the Royal Meteorological Society*, 141:563–579, 2015.

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philipp.weiss@physics.ox.ac.uk